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DIMENSIONALITY OF ABILITY-REQUIREMENTS FOR GENERIC JOB ACTIVITIES

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DTIC QUALITY INSPECTED 4

19990909 144

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REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE July 1999	3. REPORT TYPE AND DATES COVERED Interim - October 1993 - June 1996	
4. TITLE AND SUBTITLE Dimensionality of Ability-Requirements for Generic Job Activities			5. FUNDING NUMBERS PE - 62202F PR - 1123 TA - A0 WU - 00	
6. AUTHOR(S) Thomas E. Powell, J.W. Cunningham, William E. Wimpee, Mark A. Wilson, Rodger D. Ballentine				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Monterey Technologies, 1143G Executive Circle, Cary, NC 27511 Psychology Dept., North Carolina State Univ., Box 7801 Psychology Dept. Raleigh, NC 27695-7801; University of North Texas, P.O. Box 13587, Denton, TX 76203-6587			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory Human Effectiveness Directorate Mission Critical Skills Division 7909 Lindbergh Drive Brooks Air Force Base TX 78235-5352			10. SPONSORING/MONITORING AGENCY REPORT NUMBER AFRL-HE-BR-TP-1999-0007	
11. SUPPLEMENTARY NOTES Air Force Research Laboratory Technical Monitor: Lt Col William E. Wimpee, (210) 536-4469				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This study presents partial results from an ongoing research effort which is investigating the linkages between taxonomies of work and human abilities. Results are presented from a cross-system comparison of the dimensions underlying ability-requirement matrices derived from three structured job analysis questionnaires and three sets of cognitive, physical, psychomotor, and sensory abilities. Exploratory factor analyses were conducted on the intercorrelations of mean ability-requirement ratings of nomothetic job elements. The Analyses produced a core set of human performance factors that were meaningful, replicable and similar between the three independent samples. Such factors might prove useful in condensing and organizing ability-requirements information and in comparing results across instruments. In some instances, they might serve as stable composite variables for such purposes as job ability-requirement estimation and job evaluation.				
14. SUBJECT TERMS Job Analysis; Occupational Analysis Inventory; Job Ability Requirement Estimation Nomothetic Job Descriptors; Job Evaluation; Taxonomies of Work Taxonomies of Human Abilities; Sensory Abilities; Job Component Analysis Human Performance Factors; General Work Inventory			15. NUMBER OF PAGES 16	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

DIMENSIONALITY OF ABILITY-REQUIREMENTS FOR GENERIC JOB ELEMENTS

Psychologists have long sought dimensions which define and explain behavior as it relates to the worlds of work and human abilities (Cunningham, Tuttle, Floyd, & Bates, 1974; Drewes, 1993; Dunnette, 1976). Several research programs have been directed toward establishing dimensions of human work and human abilities. Although classification efforts in these two domains have produced promising results, they have proceeded largely independently. The result has been two differing taxonomic thrusts which have implications in the area of human performance. Several authors have called for research which explores the linkages between these two taxonomic worlds. In the present research, the job component approach proposed by McCormick (1979) was used to investigate these linkages.

The job component approach involves (a) the development of a general, universal set of job elements (components) and (b) the establishment of ability-requirement weights for those job components. The weights, which can be established using subject matter experts, represent the extent to which the abilities are required for successful performance relative to the job components. Subsequently, these ability-requirement estimates can be derived for any job that is rated or scored on the job components (e.g., Cunningham et al; 1983; McCormick, DeNisi, & Shaw, 1979; Sparrow, 1989). For research purposes, these estimates can provide a basis for investigating the linkages between the taxonomic worlds of work and human abilities (Peterson and Bownas, 1982).

The present study explored linkages between work and human ability taxonomies by investigating the dimensionality of ability-requirement matrices derived from three sets of

general job elements. For that purpose, exploratory factor analysis was regarded as an appropriate analytical tool. The hypothesis was that a given ability-requirement matrix, derived for a set of general work descriptors and a set of defined human abilities, could be reduced to a smaller set of meaningful human performance dimensions. To investigate this hypothesis in a way that would provide evidence for the convergent validity of the results, we analyzed three independently developed matrices.

METHOD

Instruments and Raters

The study involved three structured job analysis questionnaires and three sets of defined human abilities. The job analysis questionnaires included the General Work Inventory (GWI; Cunningham, Wimpee, & Ballentine, 1990), the Occupation Analysis Inventory (OAI; Cunningham, Boese, Neeb, Pass, 1983), and the Position Analysis Questionnaire (PAQ; McCormick, Jeanneret, & Mecham, 1972). Each of 217 GWI job elements was rated by job analysts, personnel specialists, and/or graduate students on 54 ability definitions in the Manual for Ability Requirement Scales (MARS; Fleishman, 1975, 1990; Fleishman & Quaintance, 1984). Each of 545 OAI job elements was rated on 36 ability definitions in the Attribute Requirement Inventory (ARI; Neeb, Cunningham, & Tuttle, 1970; Cunningham, et al, 1983). Each of 182 PAQ job elements was rated on 49 ability definitions compiled by McCormick and his associates (Mecham, 1968; Marquardt & McCormick, 1972).

Procedures

A job element's estimated requirement for a particular ability was derived by computing a mean from several judges' ratings. This produced from each of the three rating sets a job element-by-ability matrix of ability-requirement weights. The ability-requirement matrix for the GWI data is represented in Figure 1.

		<u>Human Attributes</u>					
		<u>1</u>	<u>2</u>	<u>3</u>	.	.	<u>k</u>
<u>Job</u>	<u>1</u>	W_{11}	W_{12}	W_{13}	.	.	W_{1k}
	<u>2</u>	W_{21}	W_{22}	W_{23}	.	.	W_{2k}
	<u>3</u>	W_{31}	W_{32}	W_{33}	.	.	W_{3k}
	<u>q</u>	W_{q1}	W_{q2}	W_{q3}	.	.	W_{qk}
<u>Components</u>	
	
	

Figure 1. Requirement weights of q job components on k human attributes.

Reliability estimates for the ratings were determined by an analysis of variance (ANOVA) procedure for estimating inter-judge agreement (Winer, 1971). A repeated-measures ANOVA

procedure was performed separately for each of the abilities, with raters as the treatment variable and the job element items as the cases on which repeated measures were taken. Using this procedure, an inter-class coefficient of reliability was computed for each ability. The inter-class coefficient can be interpreted as an estimated correlation between the mean ability-requirement rating profile of the job elements and a hypothetical mean profile derived from a new sample of raters drawn randomly from the same population.

Separate factor analyses were performed on complete GWI, OAI and PAQ ability requirement matrices. All abilities within each matrix were inter-correlated based on their job element weights (217 GWI job elements, 545 OAI job elements and 182 PAQ job elements), and the resultant correlations were subjected to principal axes factor analysis using R-squares as communality estimates, followed by varimax rotation. In order to determine the number of factors to be rotated the scree test was applied and eigenvalue plots were examined for breaks or discontinuities. Following factor rotation, coefficients of congruence (Gorsuch, 1974) were computed as indices of factor replication between factors that were judgmentally matched between the three solutions. In addition, for the GWI data, the total sample of raters was divided into two comparable subsamples, and subsample data were subjected independently to the previously described analysis. Coefficients of congruence were then computed between factors across subsamples as indices of factor stability.

A second set of analyses involved only matching abilities. That is, the procedure described above was carried out on those abilities which the data sets had in common. Factor interrelationships between data sets were then estimated via coefficients of congruence.

RESULTS

An estimated reliability was computed for the mean ratings of the job elements on each ability. In general, the ability-requirement ratings showed substantial reliability with more than 90% percent of the abilities across the three data sets obtaining an estimated interrater reliability of .80 or higher. Based on these results it was concluded that the ability-requirement estimates were sufficiently stable for research purposes.

The results from the first set of factor analyses provided a basis for judgmental comparison across the three data sets. Using the previously mentioned criteria 10 factors were rotated in the GWI and OAI analyses and eight factors were rotated in the PAQ analysis. The factor titles and the percent of variance accounted for are listed in Table 1. Table 1 also presents the coefficients of congruence calculated from the GWI subsample analyses.

Six apparent common factors were identified between the three solutions. The titles of these factors were: Strength and Stamina, Equipment-Control Sensory and Motor Abilities, Manual Abilities, Reasoning and Problem Solving, Numerical Abilities, and Visual Field Perception. Two dimensions, Verbal Abilities and Auditory Abilities, emerged from the GWI and OAI data sets, but not from the PAQ data. Four additional factors, though meaningful, were unique to one

solution: Written Comprehension and Closure (from the GWI analysis), Aesthetic Abilities (from the OAI analysis), and Taste-related Abilities (from the PAQ analysis).

The results from the factor analyses on matching abilities provided a basis for empirical comparison between the three solutions. Table 2 presents the factors derived from the GWI and OAI matching abilities. Tables 3 and 4 present the results from the GWI-PAQ and OAI-PAQ analyses.

Table 1. Human Performance Dimensions Derived from GWI, OAI, And PAQ Ability Requirement Data

GWI		% Var.	OAI		% Var.	PAQ		% Var.
			Factor Code and Title					
SS:	Strength and Stamina (.98) ^a	19.73	SS:	Strength and Stamina	8.42	SS:	Strength and Stamina	27.24
EC:	Equipment-Control Sensory and Motor Abilities (.97)	13.70	EC:	Equipment-Control Sensory and Motor Abilities	8.11	EC:	Equipment-Control Sensory and Motor Abilities	3.76
Mn:	Manual Abilities (.95)	10.10	Mn:	Manual Abilities	10.98	Mn:	Manual Abilities	5.32
RP:	Reasoning/Problem Solving (.87)	8.23	RP:	Reasoning/Problem Solving	7.81	RP:	Reasoning/Problem Solving	21.78
Nm:	Numerical Abilities (.92)	5.17	Nm:	Numerical Abilities	4.23	Nm:	Numerical Abilities	3.04
VP:	Visual Field Perception (.83)	3.17	VP:	Visual Field Perception	7.17	VP:	Visual Field Perception	17.15
Vb:	Verbal Abilities (.92)	12.32	Vb:	Verbal Abilities	8.68	--		
Ad:	Auditory Abilities (.96)	7.99	SH:	Speech Hearing	3.48	--		
WC:	Written Comprehension	2.66	--		--	--		
Cl:	Closure	2.62	--		--	--		
--			As:	Aesthetic Abilities	3.32	--		
--			BE:	Body Equilibrium	1.88	--		
--			--		--	Mc:	Mechanical Ability	2.23
--			--		--	Ts:	Taste-related Abilities	3.16

^a The coefficients of congruence were based on GWI sub-sample analyses.

Table 2. Coefficients Of Congruence Between GWI And OAI Based Factors

Factor	SS	EC	RP	Mn	Nm	VP	Vb
SS	.90						
EC	.29	.91					
RP	-.33	-.20	.87				
Mn	.43	.51	-.35	.95			
Nm	-.27	-.19	-.04	.02	.84		
VP	-.02	.09	.10	.21	.10	.87	
Vb	-.40	-.40	.74	-.37	.18	-.22	.85

SS=Strength and Stamina; EC=Equipment Control-Sensory and Motor Abilities; RP=Reasoning/Problem Solving; Mn=Manual Abilities; Nm=Numerical Abilities; VP=Visual Field Perception; Vb=Verbal Abilities.

Table 3. Coefficients Of Congruence Between GWI And PAQ Based Factors

Factor	SS	EC	RP	Mn	Nm	VP
SS	.93					
EC	.61	.76				
RP	-.15	.23	.88			
Mn	.62	.41	-.30	.91		
Nm	-.39	-.21	.40	-.08	.94	
VP	-.01	-.13	-.10	.26	.20	.64
Vb	-.43	-.52	.75	-.37	.22	-.44

SS=Strength and Stamina; EC=Equipment Control-Sensory and Motor Abilities; RP=Reasoning/Problem Solving; Mn=Manual Abilities; Nm=Numerical Abilities; VP=Visual Field Perception; Vb=Verbal Abilities.

Table 4. Coefficients Of Congruence Between OAI And PAQ Based Factors

Factor	SS	EC	RP	Mn	Nm	VP
SS	.87					
EC	.58	.48				
RP	-.18	-.23	.87			
Mn	.60	.20	-.38	.93		
Nm	-.26	-.05	.30	.00	.78	
VP	-.03	-.15	-.02	.16	.23	.74
Vb	-.18	.01	.44	-.13	-.10	-.18

SS=Strength and Stamina; EC=Equipment Control-Sensory and Motor Abilities; RP=Reasoning/Problem Solving; Mn=Manual Abilities; Nm=Numerical Abilities; VP=Visual Field Perception; Vb=Verbal Abilities.

DISCUSSION

The main purpose of this study was to investigate the factors underlying ability-requirement matrices derived from mean ability ratings of general job elements. The factors that emerged from the overall analyses were meaningful and similar between three independent data sets based on different instruments. This suggests some redundancy in the ratings of job elements on large numbers of abilities. It also suggests the job component approach is a viable approach to investigating the linkages between taxonomies of work and human abilities.

The coefficients of congruence for matched factors on the main diagonals of Tables 2-4 are substantially larger than the off-diagonal coefficients for non-matching dimensions. These

results were obtained using different job analysis instruments and different samples of raters. This evidence suggests that the factors are replicable. As further evidence of factor replicability, coefficients of congruence for GWI sub-sample data (Table 1) were all acceptably large.

Factors such as those derived in this study might prove useful in condensing and organizing ability-requirement information and in comparing results across instruments. In some instances, they might serve as stable composite variables for such purposes as job ability-requirement estimation and job evaluation. Research currently under way will derive factors from jobs' ability-requirement estimates based on job component methodology, and from direct MARS ratings of Air Force enlisted occupations. Future research might apply confirmatory factor analyses to ability-requirement data in order to further support the hypothesized structure.

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